STEM-based Digital Assessment Application for Elementary School Teacher Education Students

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Abstract. This study aimed to determine the needs of prospective elementary school teacher students in using the STEM (Science, Technology, Engineering, and Mathematics) approach and to produce STEM-based digital assessment application products that follow the independent curriculum. The methods used were interviews, Focus Group Discussions with lecturers and students of Elementary School Teacher Education at Universitas Muria Kudus, and literature studies. FGD was chosen as a substitute for direct trials in the field and became the basis for validating the feasibility of product development. The results show that students as prospective teachers do not yet have experience and knowledge of references with the STEM approach used in learning and the required assessment instruments according to the independent curriculum. The FGD process found that the STEM approach can be made in a web-based digital assessment application that is considered easy to use anywhere and anytime. The conclusion obtained is that the application of STEM-based digital assessment is an application that provides a source of reference on digital literacy and STEM, as well as creates assessment instruments that students can use as prospective teachers in implementing STEM-based digital assessments.

1 Introduction

Along with the times, information technology in education is critical, especially in teaching and learning activities, to achieve educational goals. Technology has been used in various teaching and learning activities, including the Internet, which has become a daily necessity. Technology and the internet are two interrelated aspects, so it would not be possible to use the internet without technology. Every educator must understand and use digital technology to benefit from digitalization. Therefore, digital literacy is needed to deal with technological developments and the internet, which is proliferating, especially for a teacher. Because in the world of education, digital technology has become an integral part [1].

Higher education is an institution that produces superior human resources and is expected to produce competent graduates according to the demands of 21st-century competence. Competent graduates are students who can master the six essential skills of literacy (reading, writing, numeracy, science, digital, finance, culture, and citizenship) and 4C competencies

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(critical thinking and problem solving, cooperation and collaboration, communication, creativity, and innovation). Higher education institutions can organize quality learning processes in academic activities using learning models and various renewable media that support 21st-century competencies.

21st-century skills are categorized as 1) ways of thinking (creativity and innovation, critical thinking, problem-solving, and decision making), 2) ways of working (communication, collaboration, and group work), 3) tools for working (information literacy and technology information communication) and 4) life in the world (life and career, personal and social responsibility) [2]. Some of the characteristics expected of 21st-century educators include a) The ability to develop relevant and quality learning materials. b) The ability to use technology effectively in the learning process. c) Ability to manage an inclusive classroom and create a positive learning environment. d) The ability to teach with a variety of methods. e) The ability to measure and evaluate student learning outcomes.

According to Arikunto [3], Assessment tools are considered necessary in a lesson because they collect data to determine to what extent, in what terms, and which part of the educational goals have been achieved. The assessment tool must be objective, practical, and facilitate the teacher. Assessment and Teaching of 21st Century Skills, according to a group of experts, is used to determine the critical skills of the 21st century [4].

21st Century Learning is imbued with 4C, where 4C communication skills, Collaboration Skills, Critical Thinking Skills, and Creative Thinking skills must constantly be developed because these skills play an essential role in responding to the challenges of the Industrial Revolution 4.0. The Industrial Revolution 4.0 is marked by the transformation in all aspects of science by empowering digital-based technological sophistication [5]. The main principles of 21st-century learning can be developed in several aspects, namely: a) Learning Must Be Student-Centered (Instruction should be student-centered), b) Learning Must Be Collaborative (Education Should be Collaborative), c) Learning Must Have Context What is clear (Learning should have context), d) Higher Education Must Be Integrated with Society (School should be integrated with society) [6].

STEM learning is already popular in developed countries like the United States. However, in Indonesia, the government is starting to pay attention to STEM learning to be included in the school curriculum. STEM in Indonesia is still developing, and no standard assessment can be explicitly applied to STEM learning [7]. The STEM approach is often interpreted as integrating four disciplines: Science, Technology, Engineering, and Mathematics [8]. In essence, the main goal of STEM Education is to train students in applying basic information and STEM disciplinary practices so they can identify, understand, and be interested in solving various problems in real life, especially regarding issues related to STEM [9]. Vasquez et.al [10] state that STEM Education as a form of effort removes barriers between Science, Technology, Engineering, and Mathematics and then integrates it into the relevant lives of students.

Through the STEM approach, students' experience in learning will be more prosperous. The STEM approach needs to emphasize the balance of each discipline, be it science, technology, engineering, or mathematics, and students are expected to be able to make new connections in two or more disciplines, as evidenced by the increased interest and involvement of students in learning [11]. Kelley & Knowles [12] illustrate a STEM learning framework such as a pulley system in which STEM learning is integrated and interconnected as a system with scientific (scientific) investigation, engineering design, technological literacy, and mathematical thinking. The STEM approach focuses on integrating science, technology, engineering, and mathematics to solve a problem in real-life situations, where each aspect has a role in the problem-solving and investigation process. An explanation of aspects of the STEM approach can be seen in Table 1.

Table 1. Aspects of the STEM approach.

Aspect	Process	Description
Science (S)	Science Inquiry	The Science (S) aspect prepares students to be able to think like scientists, actively ask questions, hypothesize, and carry out scientific investigations based on scientific standards
Technology (T)	Technology Literacy	Technology (T) or technology as a process that involves activities using technology, both in terms of designing and manufacturing something
Engineering (E)	Engineering Design	The Engineering (E) aspect relates to the engineering design process, which enables students to build knowledge of science and mathematics through design analysis and scientific investigation
Mathematics (M)	Mathematical thinking	Aspects of Mathematics (M), namely the use of mathematical concepts or mathematical thinking in the process of scientific investigation

The essence of STEM education is to train students to be able to master 21st-century skills so that they can apply the knowledge gained in the classroom or laboratory to future jobs [13]. With collaboration, it is hoped that learning, both in terms of experience and mastery of content, can produce cross-disciplinary ideas, which are the essence of the STEM approach [14]. The STEM learning approach has various advantages, one of which is integrating several disciplines to be suitable for developing 21st-century skills [15]. Sujarwanto, E [16] states that the principles of the STEM learning process are the principles of the design process, the principles of the inquiry process, problem-centered, cooperative-oriented, and the integration of teaching materials. The principles that have been identified will help support the development of STEM integration learning models. Several research results have shown that STEM learning successfully trains skills 21 [17-20]. Based on this description, this study aims to develop a STEM-based digital assessment application that can be used by prospective teacher students in elementary school teacher education study programs.

2 Methods

This study uses a qualitative approach regarding the needs of prospective teachers (PGSD students) in studying the reference *STEM approach model* and the design of STEM-based digital assessment applications. This study used in-depth interviews, focus group discussions, and literature studies. The Focus Group Discussion (FGD) method was chosen as a substitute for direct trials in the field. The FGD involves people considered competent in analyzing needs and conditions in the field. The product development process through trials and revisions is carried out through these activities. The agreement obtained in the FGD is used as the basis for product feasibility validation. In this study, the researcher acted as the main instrument in the data collection process, equipped with guidelines for conducting FGD activities and in-depth interviews. The data in this study is divided into primary data and secondary data. Primary data were obtained from lecturers and prospective teacher students at PGSD Universitas Muria Kudus. Meanwhile, secondary data is obtained through the information in documents or research notes.

3 Results and Discussion

The interview process resulted in several matters relating to the problems encountered in the learning process in making assessments that follow changes in the education curriculum, the

use of the *STEM approach*, the experience of looking for references to STEM-based learning, especially in the required assessments, and the need for other reference sources related to assessment. Regarding the aspects of the problems encountered in the learning process, student teacher candidates suggest that in the aspect of making assessments with the *STEM-based assessment application approach*, it can be tried to be a solution to overcome these problems. However, in terms of the experience of looking for references related to assessment with the STEM approach, they have not been able to get the correct and appropriate references because they still do not understand. Therefore, in terms of the need for STEM-based digital assessment reference sources, it is hoped that there will be a complete but easy source. They proposed a solution that should reference learning models that can be accessed easily anywhere and anytime. So they also want an efficient application for them in preparing themselves as prospective teachers who must be able to keep up with changes in the education curriculum, which in this case is an independent curriculum.

Furthermore, the results of the interviews were discussed in the *FGD stage*. The *FGD* process states that STEM-based digital assessment is appropriate for development. The discussion focused on platform selection, display design, and user experience. In selecting the platform, it can be concluded that the product is made on a platform that can be accessed using a computer or *Android phone* as an application via a website. In the design aspect of the display design, it can be concluded that it must be able to make it easier for application users to read and understand any information provided, and the display must have an attractive design. In the aspect of user experience, it can be concluded that the application must provide several assessment instruments adapted to the new curriculum, namely the independent curriculum. The *FGD* process continues to be carried out to get the best results by conducting a product revision process.

Based on the results of the FGD, the STEM-based digital assessment was named "*DIGASS*." The application design is then made based on the results of the *FGD*. The Digass application system was created by designing a UML (Unified et al.) model, using the PHP programming language, using Bootstrap 5 as a front-end framework, using Mysql as a system database, using Notepad++ to implement the PHP programming language in making the system (including the design or appearance), using Apache as a web server (connecting server (system) and users using browsers). The testing method used is the Black Box Testing method.

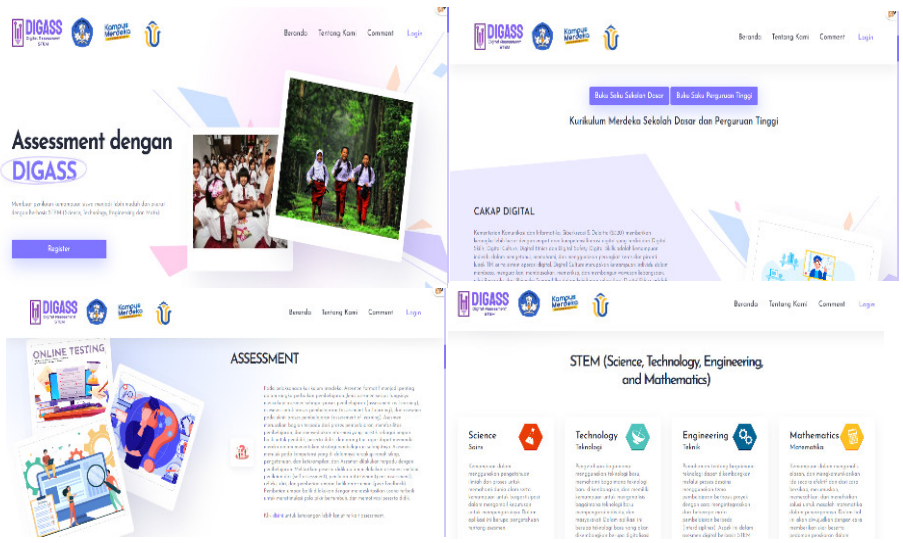
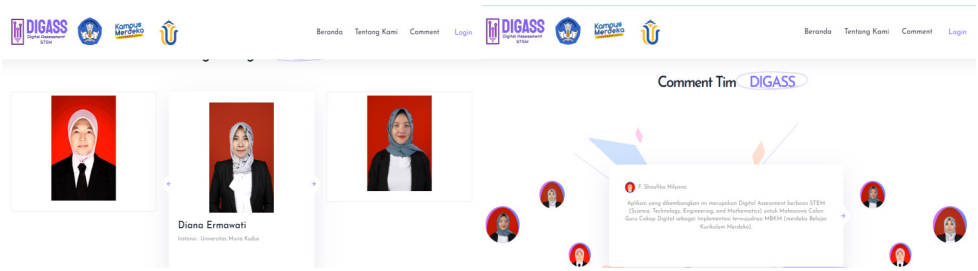


Fig. 1. Appearance of the application's main menu.

The STEM-based digital assessment application is adapted to the theme taken from the name and use of the independent curriculum. The display of icons, components, buttons, and backgrounds in the application is adapted to the theme so that it is easy to recognize the media used. One dominant color is chosen as the primary color of the application, and other different colors characterize each learning device. To make it easier to use the application, content is divided into several main display menus, including Home, About Us, Comments, and Login. Before logging in, we must register first, as well as reference materials on the independent curriculum, digital literacy, assessment, and STEM, as well as the application development team (Figure 1).

Each icon can be selected for the next step or explanation according to the icon title. All material documents are accompanied by a link that can be displayed directly for a more complete explanation. The main menu that appears when pressed on the 'about us button can be seen in Figure 2a, and the 'comment' button can be seen in Figure 2b.



(a) (b)

Fig 2. Display of icons (a) about us, and (b) comment.

Next is a second menu, namely, the menu after logging in. Before logging in, we will be directed to register first for an account according to the application user. After logging in, the user will enter the application account, as shown in Figure 3. The user can read the material and can choose what he wants to do, namely, the assessment link, which consists of the instrument, the contents of the instrument, and the assessment; the archive link, consisting of Assessment results and classes, and settings link, consisting of user, class, and class enroll.

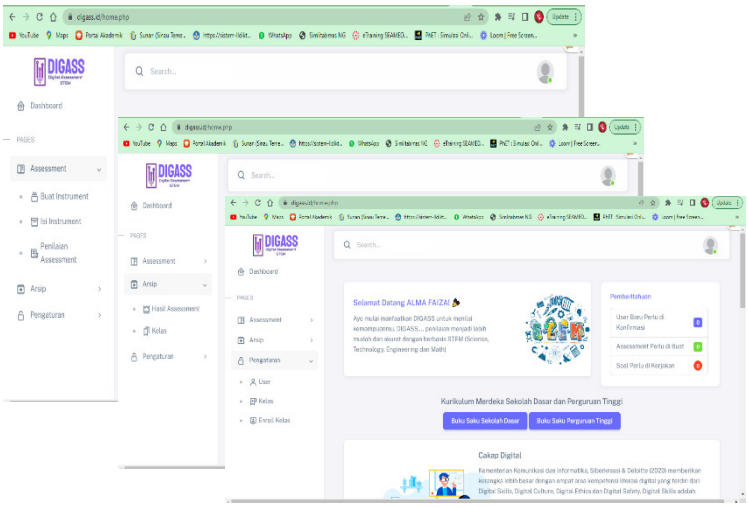


Fig 3. User account menu display.

The menu that appears on the dashboard page at the bottom is the “Contact Us” menu (Figure 4). This menu can help with the application through a telephone number or email. The profile of the creator of each content contained in the application is displayed in that section. In addition, there is information about the application version being used so that users can find out if an update is available for the application.

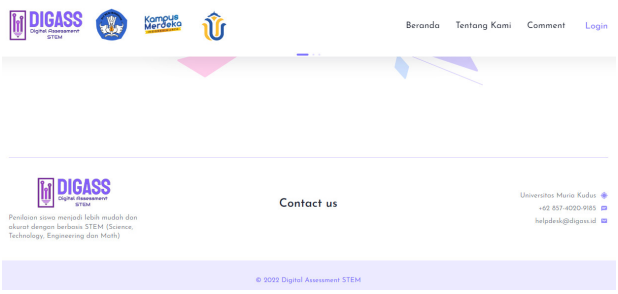


Fig 4. Display of the dashboard page menu at the bottom " Contact Us."

This research develops the creation of a STEM-based digital assessment application. This tool can be used as a reference for prospective teachers who need to make assessments in learning according to the independent curriculum. According to Pratama Sujatmiko [21], Assessment is an analysis used to dig up information in the world of education and others. Assessment is an integrated part of the learning process, learning facilitation, and providing holistic information as feedback for students to guide them in determining further learning strategies. The assessment is designed and carried out according to the function of the assessment, with the flexibility to determine the technique and time of implementation of the assessment so that it is effective in achieving learning objectives.

Educators are encouraged to carry out assessments, which include formative assessments, summative assessments, and diagnostic assessments. The flexibility includes designing the assessment, implementation time, using assessment techniques and instruments, determining the criteria for achieving learning objectives, and processing the assessment results. Learning objectives. This can be done by using descriptions, rubrics, scale value intervals, or other approaches according to the needs and readiness of educators to develop them [22]. It is hoped that the digital assessment developed can help improve digital literacy by achieving the objectives of the assessment made; this is in line with the assessment application developed by [23], which can also improve the objectives achieved to be more optimal.

The development of this STEM-based digital assessment is made web-based, with the intention that assessment data can be quickly identified [24], and with other advantages such as the practicality of accessing data anytime and anywhere, being able to create assessment instruments, schedule assessments, and correct answers with grades, which was determined at the outset. This is to the advantages of the web stated by Alfran et al. [25], who stated that the advantages of this web evaluation are that it is practical, can be accessed anytime and anywhere for free, there are various types of questions so that they can attract students' attention, can correct student answers automatically and can know the score directly. The drawback of this web evaluation is that it can only be used online. Therefore, by presenting a digital-based assessment application, STEM can fulfill this reference need.

Aspects of the STEM approach in the development of assessment applications can be seen on the application dashboard page (Figure 5), which includes Science, Technology, Engineering, and Mathematics, which can be explained in Table 2.

Fig 5. STEM aspects that are visible on the application Dashboard.

STEM has four characteristics and is defined and described by Torlakson [26], namely: (1) science, which represents knowledge about the laws and concepts that apply in nature; (2) technology is a skill or a system used in managing society, organization, knowledge or designing and using an artificial tool that can facilitate work; (3) engineering or engineering is the knowledge to operate or design a procedure to solve a problem; and (4) mathematics is a science that links quantities, numbers and space which only requires logical arguments without or accompanied by empirical evidence. All of these aspects can make knowledge more meaningful if it is integrated into the learning process.

Table 2. Aspects of the STEM approach.

Aspect	Description
Science (S)	Knowledge of assessment.
Technology (T)	The new technology that will be developed is in the form of digitization or online in the manufacture and execution of assessments.
Engineering (E)	Students can make various assessment forms for different subjects and later adapt to the independent curriculum.
Mathematics (M)	Provide scores and scoring guidelines in making digital assessments that students will carry out.

STEM is a scientific discipline that is closely related to one another. STEM-based Digital Literacy (Science, Technology, Engineering, Mathematics) is critical because it closely relates to 21st-century learning [27]. STEM-based Digital Literacy is an alternative learning that has the potential to be used to build 21st-century skills. Digital literacy uses information and communication technology (ICT) to communicate content/information with cognitive and technical skills [28].

Four indicators of digital literacy skills are presented: 1) internet searching, 2) hypertextual navigation, 3) content evaluation, and 4) knowledge assembly. The application of digital literacy is an activity that has a positive value towards improving the ability of students with excellent digital literacy by mastering the media in searching for information so that they are not stuttered by technology so that it is easy to use and utilize digital devices that support information search and determine the website to obtain information because it understands the characteristics of a website. Process various information, understand messages, and communicate effectively with others to understand when and how technology must be used to be effective in achieving goals [29].

The assessment is intended to be used as an assessment instrument that aligns with the characteristics of the subjects, learning outcomes, learning objectives, and the needs of students. It is not only focused on summative assessments, so there are choices of assessments

for the realm of knowledge, attitudes, and skills. So that the types, techniques, and assessment instruments can be known and students can own the description of the best criteria. This assessment can also be addressed to users according to a specified schedule.

Through education, a person is prepared to have the provision to be ready to know, understand, and develop methods of thinking systematically to be able to solve problems that will be faced in life in the future. Indonesia must immediately prepare professional educators who can use technology to prepare a competent millennial generation. The Minister stated that human resources must be prepared to be responsive, adaptive, and reliable to face the industrial revolution.

Learning using the STEM approach directly trains students to integrate each aspect simultaneously. The learning process involving all four aspects will shape knowledge about the studied subject more understandably [30]. STEM-based learning can train students to apply their knowledge to create designs to solve environmental problems by utilizing technology [31]. In Malaysia, the development of STEM education is an essential agenda for educational transformation and preparing students to face the challenges of the 21st century [32]. Therefore, the digital assessment application-based STEM has a good impact on increasing digital literacy competencies and providing success for prospective teachers in making assessments and understanding STEM.

4 Conclusion

The assessment is designed and carried out according to the function of the assessment, with the flexibility to determine the technique and time of implementation of the assessment so that it is effective in achieving learning objectives. The development of this STEM-based digital assessment is made web-based with other advantages such as being practical where data can be accessed anytime and anywhere, making assessment instruments, scheduling assessments, and correct answers with predetermined values at the start of their manufacture. The assessment is intended to be used as an assessment instrument that aligns with the characteristics of the subjects, learning outcomes, learning objectives, and the needs of students. So, the digital assessment application-based STEM has a good impact on increasing digital literacy competencies and providing success for prospective teachers in making assessments and understanding STEM.

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